SAND2004-2618P

Enabling dose profiles for forward Monte Carlo radiation transport with CAD geometry models

Volumes of part intersections with cells

August 1st, 2002

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Overview

Enabling dose profiles for forward Monte Carlo Radiation Transport with CAD geometry models

Forward MCRT

- Integrated Tiger Series(ITS)
  - What does it do?
  - How does it represent real life scenarios?

Overview

Enabling dose profiles for forward Monte Carlo Radiation Transport with CAD geometry models

CAD

- Why use CAD representation of models?
- How does it integrate into ITS?

Overview

Enabling dose profiles for forward Monte Carlo Radiation Transportwith CAD geometry models

Dose Profiles

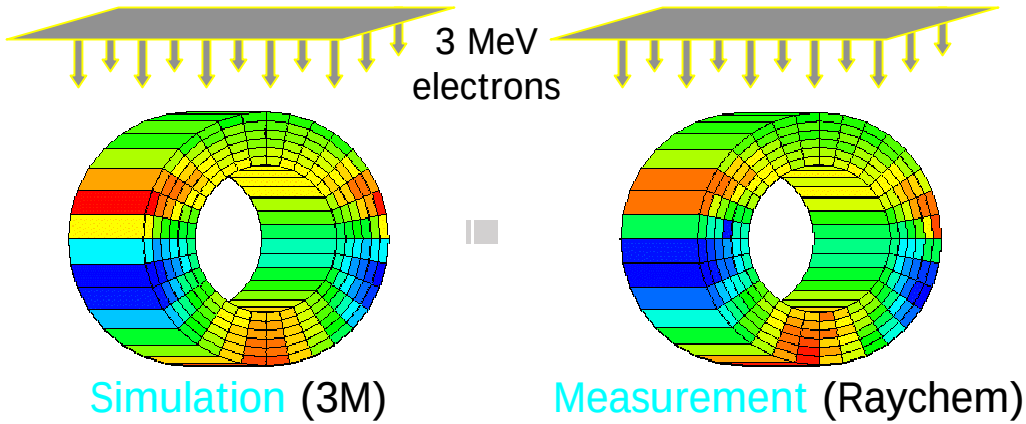
- What method was needed for the dose profiling to work?
- How was that method implemented?
- How was that method tested?

Integrated Tiger Series(ITS)

ITS (Integrated Tiger Series) permits a state-of-the-art Monte Carlo solution of linear time-integrated coupled electron/photon radiation transport problems with or without the presence of macroscopic electric and magnetic fields of arbitrary spatial dependence

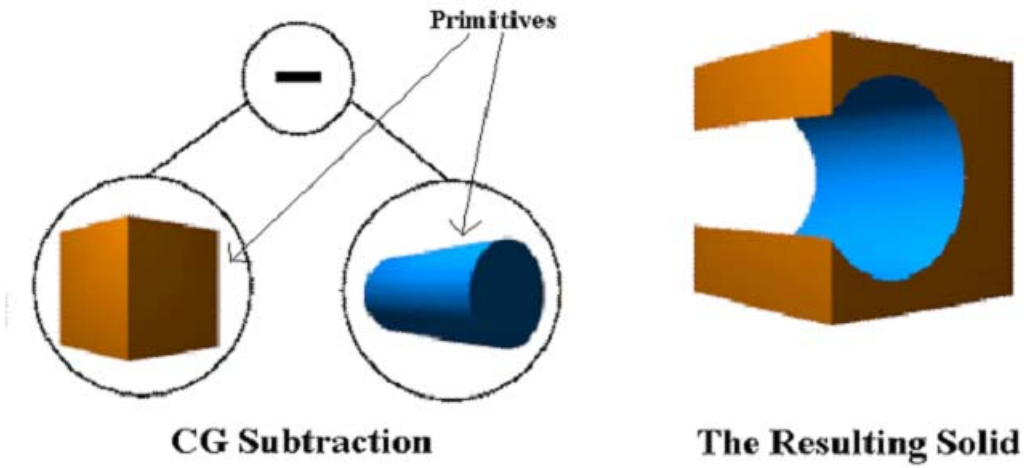
How is that useful?

ITS allows designers to predict product performance in radiation environments



Combinatorial Geometry Representation

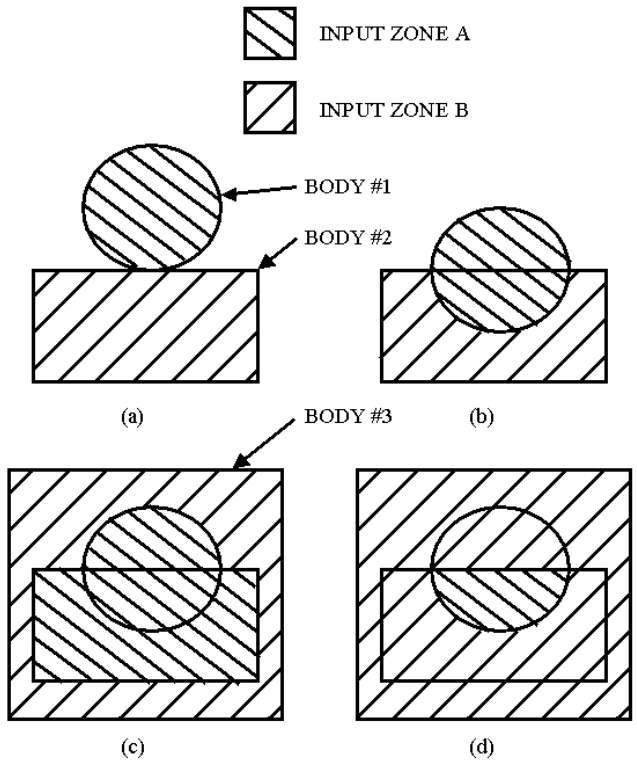
- In a CG representation, each model is built from Boolean combinations of primitives
- These combinations form a tree of primitives and set operations such as unions, intersections and subtractions



Input Zones

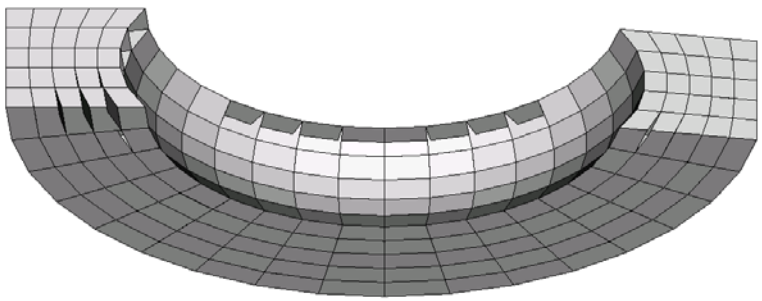
- ITS represents the problem geometries by resolving them into a set of input zones.
- Each input zone is defined as a region of space filled with a single homogenous material or a void.
- These input zones are built by using the CG primitives built into ITS.

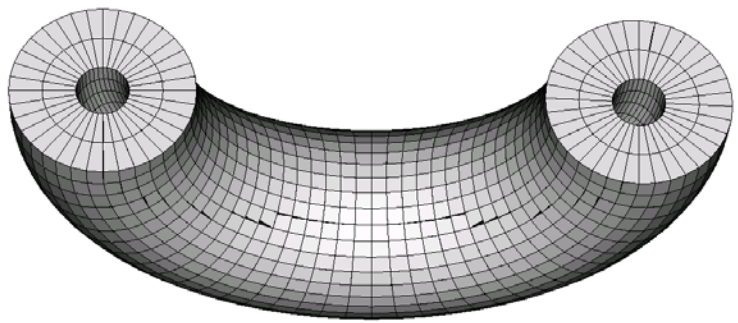
Input Zones



Subzoning

- Subzoning is a feature of ITS where the user directs the code to internally divide a given input zone into subzones for the purpose of obtaining the spatial variation of energy and charge deposition, electron flux, and photon flux within the given input zone
- This is accomplished by overlaying the subzone cells with the CAD model and calculating the volume enclosed by each individual cell





What's the problem?

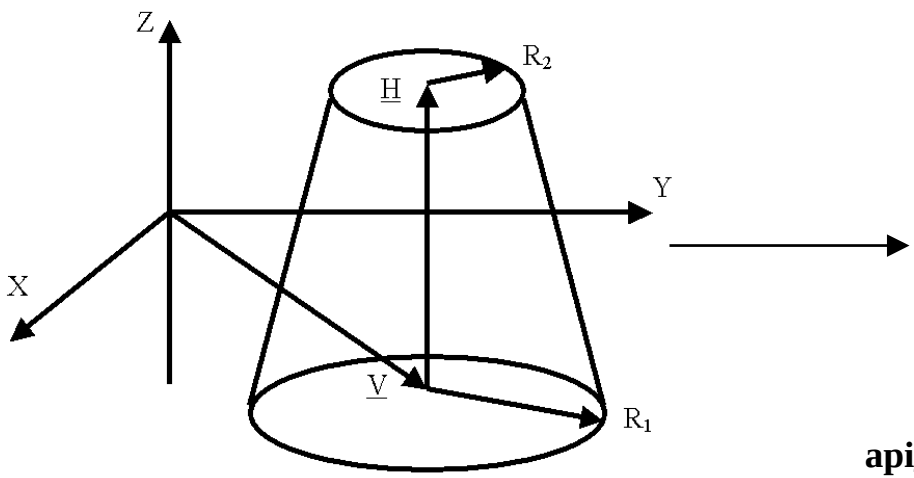
- ITS does not have the capability to subzone CAD models
- Without full CAD compatibility, forward runs of ITS require a CG representation of the model
- CG representations have taken up to a year to build for complex models such as satellites

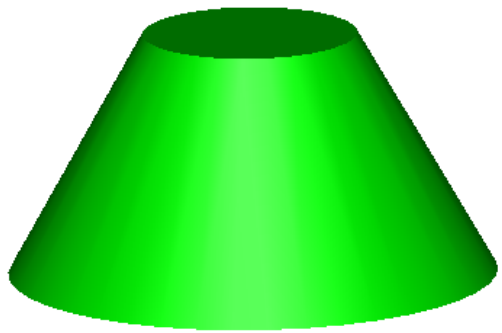
Solution?

- Represent the ITS primitives in ACIS
- Slice the primitives into the cells required for subzoning
- Transform those cells into the correct position
- Calculate the volume and store

Primitive Representation

First Goal: Represent the ITS CG primitives input file description in ACIS 6.0





api_make_frustum(height, rad1, rad2, top, body)

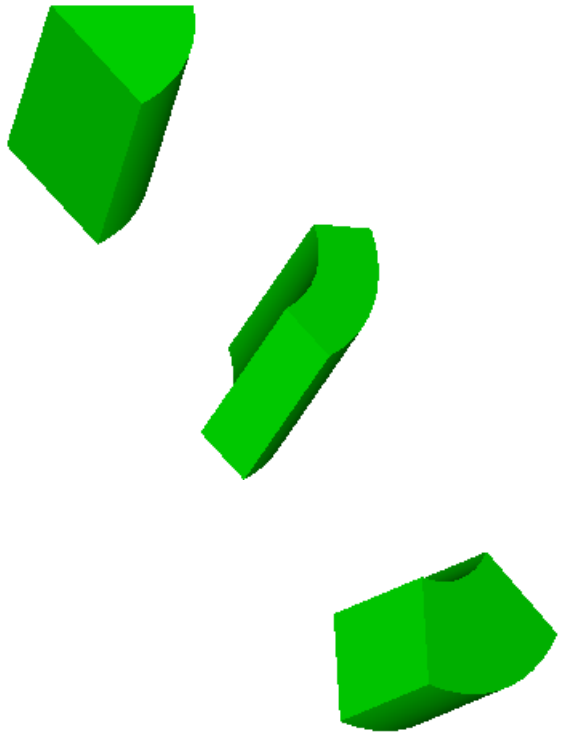
Primitive Mapping

Each of the CG primitives was mapped to an api_make command. These api_make calls created simple geometries in ACIS and would be the easiest way of implementing the CG primitives

CG Primitive	API_MAKE_
Box, Wedge, Right Parallel Pipette	Cuboid
Right Circular Cylinder, Truncated Right Cylinder	Frustum
Torus	Torus
Sphere	Sphere

Slicing

Second Goal: Slice the primitives into divisions along the radial (rho), azimuthal (phi) and z-axes



Slicing bodies with a plane

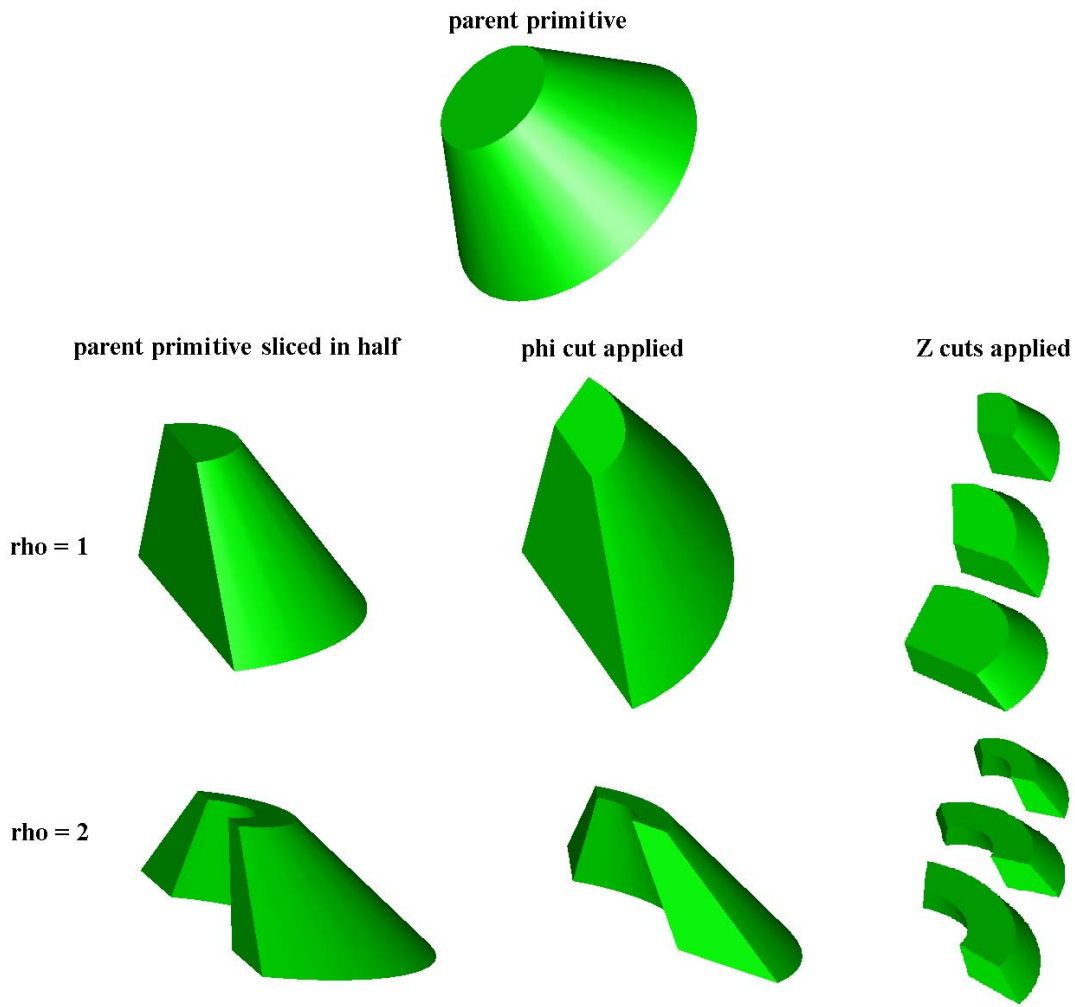
Method:

- **Radial slices performed by subtracting the n-1 body**
- **Z and phi slices performed by cutting with a plane**

Implementation:

- **The current radial cut will be stored so it can be subtracted from the next radial division**
- **Plane is an ellipse with diameter larger than the bounding box of the body that is covered with a face**
- **It will be joined with the body by using the api_intersect command**

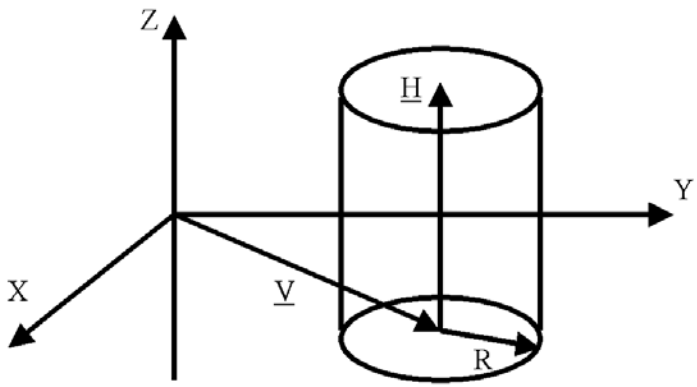
Cell Geometries



Transformation Schemes

Three options were explored

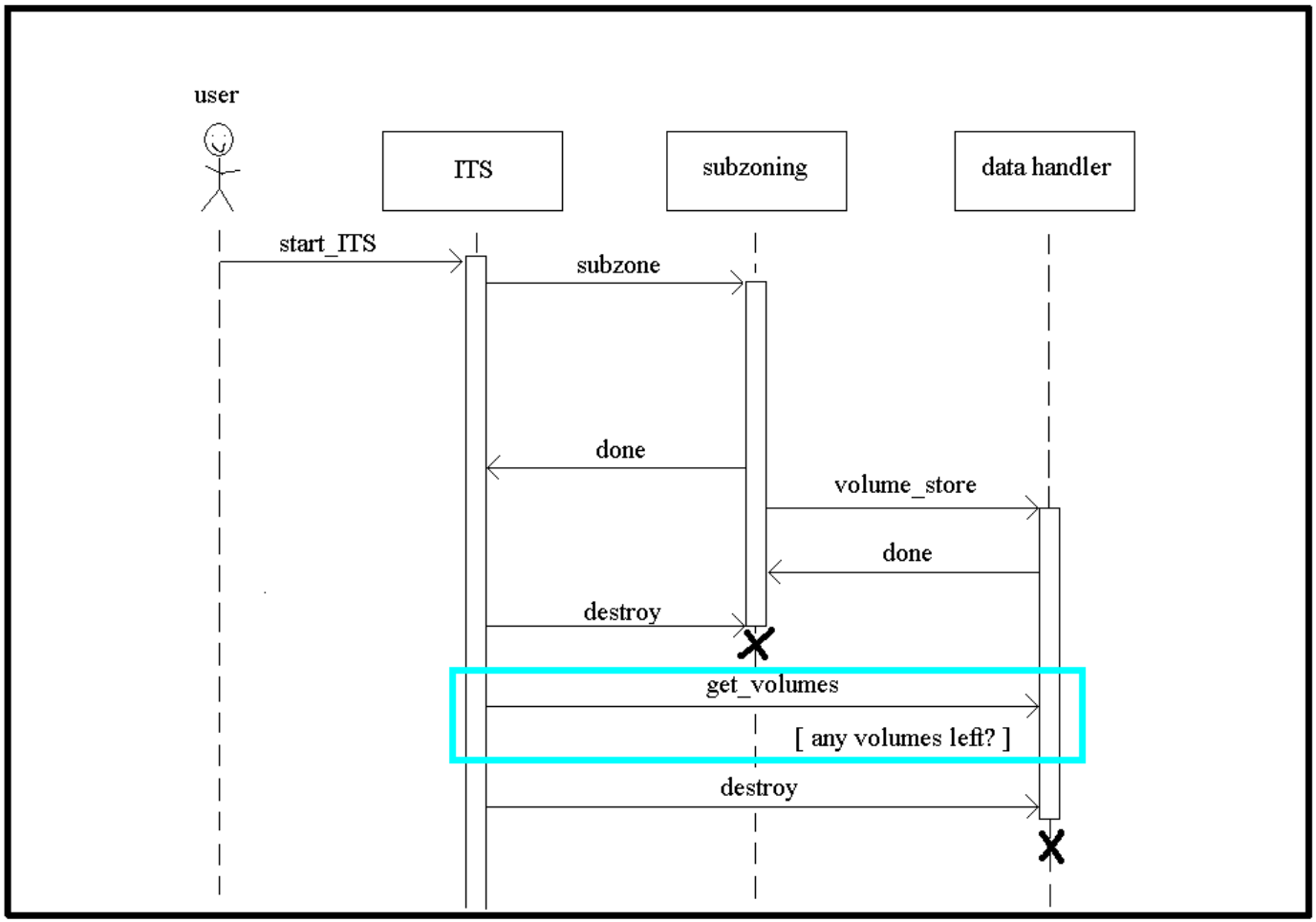
1. Move the cells to the CAD body
2. Move the CAD body to the Cells
3. Move the Coordinate system



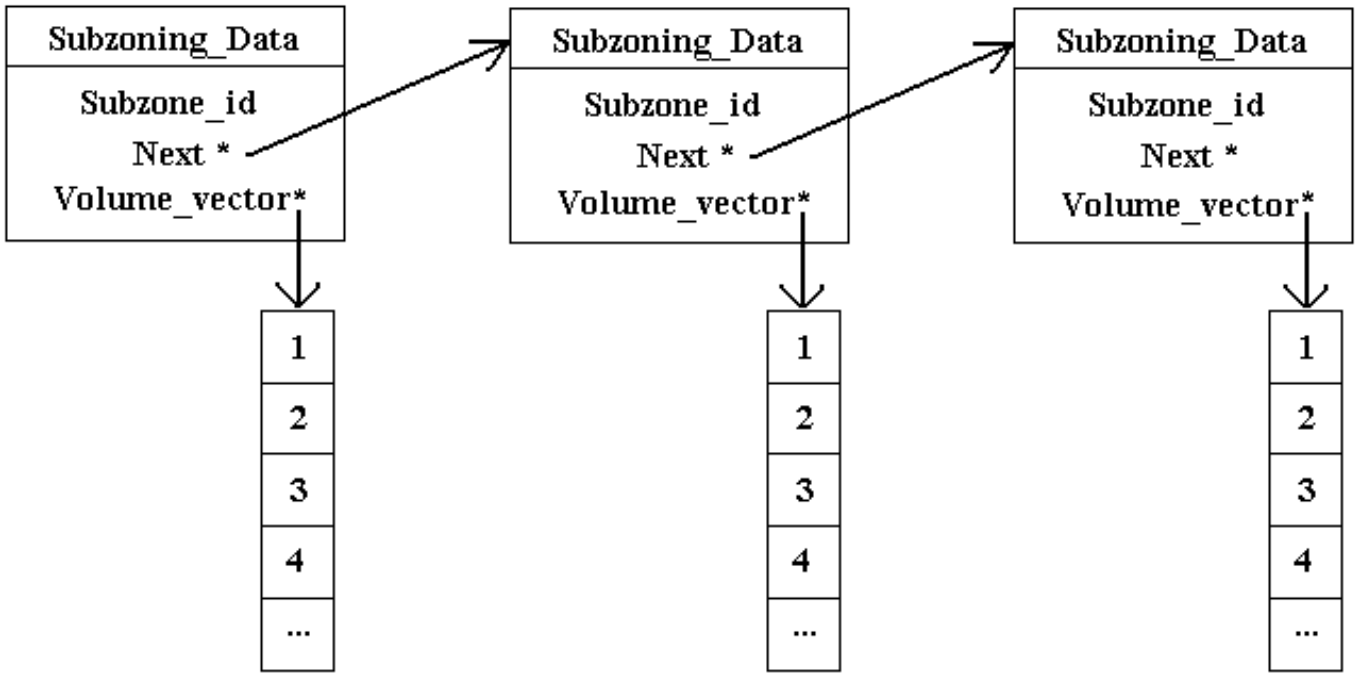
Program Requirements

- **Basic Course**: The user sets the CAD subzoning option in the input file to ITS. The user executes ITS which then makes a subzoning request. The subzoning is carried out and the volumes are stored. ITS then requests the volumes at a later point in its execution path.
- **Alternate Course**: If the user entered improper subzoning values, or the subzoning fails the user receives an error message and program execution stops.

Program Flow



Data Handler



Tests & Validation

- All cells were visually inspected
- Subzoning CAD representations of CG primitives centered around the origin and then analytically calculating the volumes
- Modified ITS regression tests with known values
- Set up all of the primitives located in arbitrary orientations in space and subzoned them. Compared results to calculated value.

Conclusion

- All required aspects of subzoning are functional except for the transformations
- Currently investigating why the transformations are not functional
  - Problem geometry not being modified correctly
  - Transformation matrix not applied correctly